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SHORT COMMUNICATION

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A shea butter rich in tocopherols (Vitamin E) at the dogon plateau and seno bankass in Mali (West Africa)

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ABSTRACT

Vitellaria paradoxa, a forest tree species plays an important role for rural populations in Mali. The kernel is rich in fat, fatty acids and tocopherols and the butter extrated from the kernel is used in many African kitchens, in pharmacology, cosmetics, local traditional medicine and as Chocolate Butter Equivalent (CBE) in chocolate industry. A consortium funded by the European Union has worked on several aspects of shea tree including chemical characterisation of shea butter. In Mali, one of the project partners, five sites were selected, fruits were collected from selected shea trees and sent to Montpellier for chemical analyses assessing among other variables the tocopherol content of the shea butter using liquid chromatography (HPLC). Results of this study shown that shea butter from the Dogon Plateau and the Seno Bankass is richer in tocopherols (Vitamin E) compared to other study sites. Sites were found significantly different for tocopherols content all together as well as for each type of tocopherol. The richness of shea butter from the Dogon Plateau and the Seno Bankass in tocopherols confers to it an important nutritional value for the good healf of rural populations of this zone, shea butter being the main source of fat for cooking in this area.

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INTRODUCTION

Vitellaria paradoxa (shea butter tree) a plant for the future

Vitellaria paradoxa, is one of the most important forest tree species of agroforestry parklands in the Sudanian and the Sudano-Guinean zones in West Africa (Plate 1). The species plays important role for rural populations. The pulp of ripen fruits is very nutritious and provides a key dietary supplement to local people, especially at the end of dry season when the stocks of staple grains are low [1]. The kernel is rich in fat, fatty acids and tocopherols [2, 3, 4].

Due to the importance of products of this tree species, a consortium of five african countries (Burkina Faso, Ghana, Mali, Ouganda, Sénégal) and five european countries (France, Germany, United Kingdom, Denmark et Sweden), has conducted a project titled "Innovative Tools and Technique for Sustainable Use of the Shea Tree in Sudano-Sahelian zone" (INNOVKAR), funded by the European Union and working on several aspects of shea tree including chemical characterisation of shea butter.

The butter (Plate 2) is used in many African kitchens but also in pharmacology, cosmetics, local traditional medicine and as Chocolate Butter Equivalent (CBE) in chocolate industry. The European continent yearly maximum nuts importation was estimated to 60,000 tons [5]. According to Koloche *et al.* [6], Mali and Burkina, in addition to Nigeria, are leading producers and exporters of shea nuts. Maranz *et al.* [3] reported that, about 10% of nut production included in the estimation of FAOSTAT [7] are exported. Collinson and Zewdie-Bosuener [8], reported that 5% of exported nut go into cosmetics manufacture and the rest (95%) goes to the food industry, principally chocolate manufacturing.

MATERIALS AND METHODS

In Mali, five sites were selected according to the north-south climatic gradient for this study (see Map 1). Selected sites were:

Plate 1: *Vitellaria paradoxa* trees in an Agroforesty Park at M'Peresso in southern Mali

Plate 2: Shea butter traditionally extracted at Solosso (San-Mali): each bag contains the butter of 5 kgs of nuts harvested from individual shea tree performant for butter production

Sassambourou at Bandiagara in the Dogon Plateau (Extreme North of shea distribution area in Mali), Tori at Bankass in the Seno (Extreme North also), Daelan at San (Segou region in the Centre of shea distribution area), Mperesso at Koutiala (Sikasso region in the South of shea distribution area) and Nafégué at Kadiolo (Sikasso region in the Extreme South of shea distribution area in Mali). In each site, fruits were collected from selected shea trees and sent to Montpellier (France) for chemical analyses. Variables like fat content, fatty acids and tocopherol content were assessed.

Vitamin E (Overview)

There are eight natural forms of vitamin E made of four tocopherols and four tocotrienols which are:

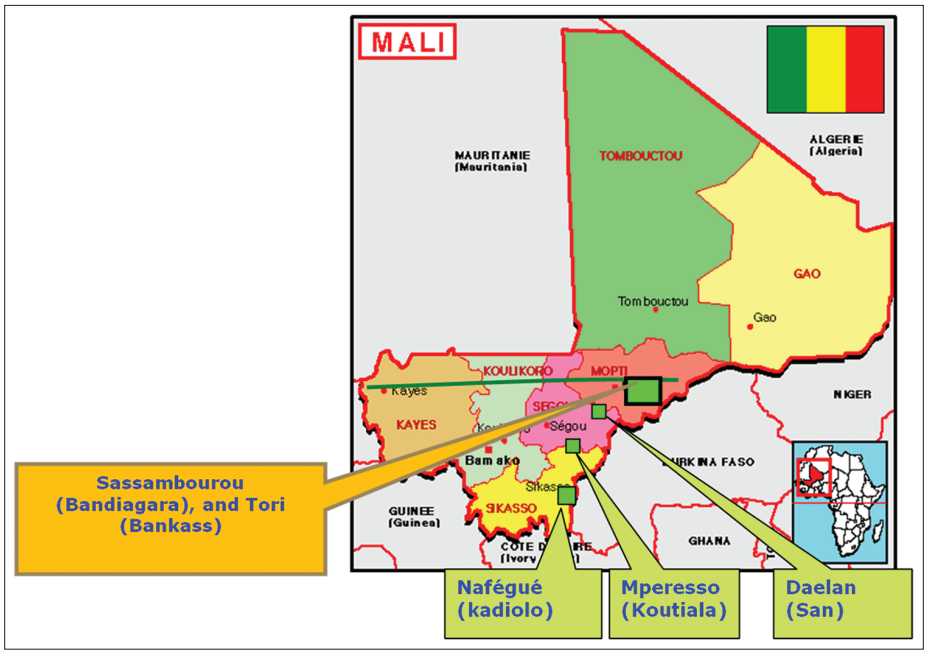
- *α*-tocopherol
- *β*-tocopherol
- *γ*-tocopherol
- *δ*-tocopherol *alpha-tocotrienol*
- *bêta*-tocotrienol
- *gamma*-tocotrienol
- *delta*-tocotrienol

The tocopherols are made of a chromanol core and a lateral chain saturated with 16 carbon atoms. The tocotrienols differ

Table 1: Shea butter tocopherols content by site

Tocopherols	Sites	Zone	Means (ppm)
All tocopherols	Sassambourou	Dogon Plateau	134,62[a]
	Tori	Seno Bankass	122,10[a]
	Daelan	Centre	90,63[b]
	Mperesso	South	117,73[a]
	Nafégué	Extreme south	83,65[b]

Ppm = Part per million; Means with the same letter are not significantly different

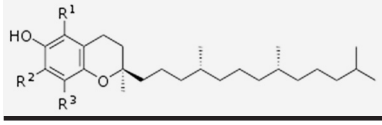


Map 1: Localisation of study sites in different regions of Mali (source: https://www.google.ml): Northen limit of *Vitellaria paradoxa* (shea) distribution area at Mali

from tocopherols by the presence of three double liaisons on this lateral chain.

The difference between alpha, beta, gamma and delta forms reside in the number and the position of the methyl groups on the chromanol core.

- **Structure and denomination of the four tocopherols**

Substituants of tocopherols	R^1	R^2	R^3	Name
	CH_3	CH_3	CH_3	α-tocophérol
	CH_3	H	CH_3	β-tocophérol
	H	CH_3	CH_3	γ-tocophérol
	H	H	CH_3	δ-tocophérol

Tocopherol esimtation method

Ripe fruits were collected from individual shea trees. Fat extraction was performed at room temperature using 3 g of shea nut powder and 12 ml petroleum ether stirred magnetically for 2 h in the dark to avoid degradation of labile compounds such as tocopherols. Solvent containing fat was filtered through 0.2 μm PTFE syringe, and then helium evaporated under hood. Fat were stored at -20 °C and protected from light. The tocopherol contents of fat were analyzed by liquid chromatography (HPLC) according to ISO 9936 (AFNOR 1997). A detailed method of chemical analysis is given in Allal *et al.* [9].

RESULTS

Tocopherols content according to sites was shown in Table 1. From this table, the Dogon Plateau and Seno Bankass revealed shea butter rich in tocopherols (Vitamin E) compared to other study sites.

The analysis of variance over all tocopherols together showed significant difference between sites regarding tocopherols content ($P < 0.0001$; anova table below).

Anova: Site effect on all tocopherols contents

Source	DDL	SS	MS	F	Pr>F
Sites	4	100209.222	25052.306	20.170	< 0.0001

SS=Sum of squares; MS=Mean squares

The site of Sassambourou in Dogon Plateau and that of Tori in Seno Bankass shown significant highest means for all tocopherols together compared to the site of Daelan in the Centre and that of Nafégué in the Extreme south.

Sites comparison according to the type of tocopherols was shown in Figures 1, 2 and 3.

•Sites comparison for α-tocopherol content was shown in Figure 1.

Sites were significantly different for α-tocopherol content ($P < 0.0001$; anova table below).

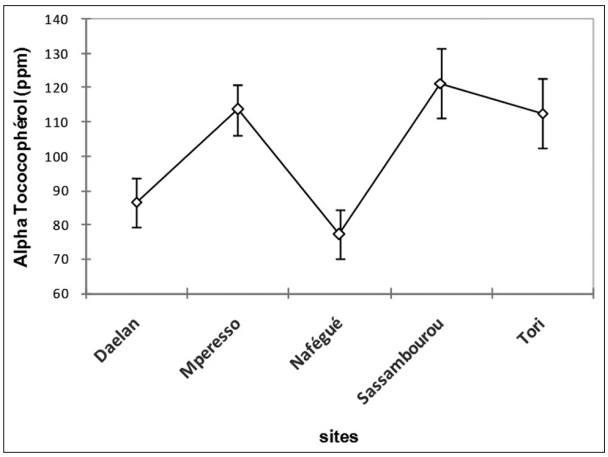


Figure 1: Mean alpha tocopherol content by site

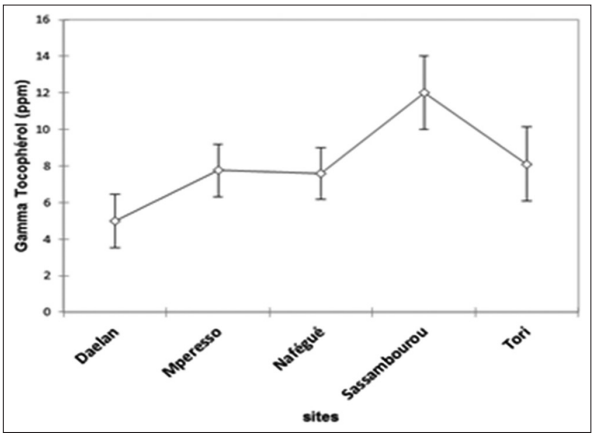


Figure 2: Mean gamma tocopherol content by site

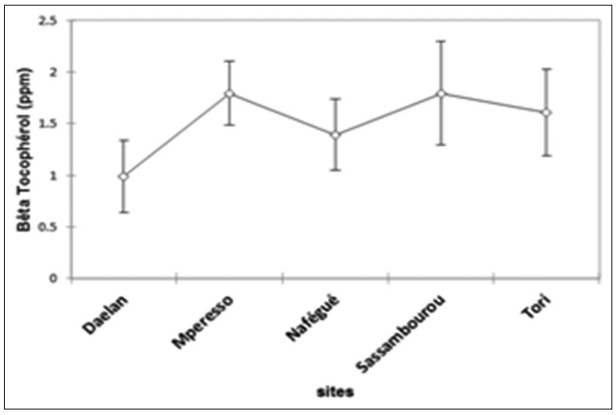


Figure 3: Mean beta tocopherol content by site

Anova: Site effect on alpha tocopherols contents

Source	DDL	SS	MS	F	Pr>F
Sites	4	83787.035	20946.759	21.896	< 0.0001

SS=Sum of squares; MS=Mean squares

Sassambourou (Dogon Plateau), Tori (Seno Bankass) and Mperesso (South) showed the highest means for α-tocopherol. These sites

were significantly different to the sites of Daelan and Nafégué.

•Sites comparison for γ-tocopherol content was shown in Figure 2.

Sites were also significantly different for γ-tocopherol content ($P < 0.0001$; anova table below).

Anova: Site effect on gamma tocopherols contents

Source	DDL	SS	MS	F	Pr>F
Sites	4	83787.035	20946.759	21.896	< 0.0001

SS=Sum of squares; MS=Mean squares

Sassambourou (Dogon Plateau) showed the highest mean for γ-tocopherol. It was significantly different to all other sites excepeted Tori (Seno Bankass).

•Sites comparison for β-tocopherol content was shown in Figure 3.

The difference between sites was significant for β-tocopherol content also ($P = 0.010$; anova table below).

Anova: Site effect on beta tocopherols contents

Source	DDL	SS	MS	F	Pr >F
Sites	4	14.418	3.605	3.483	0.010

SS=Sum of squares; MS=Mean squares

Sassambourou (Dogon Plateau) and Mperesso (South) showed the highest means for β-tocopherol. They were not significantly different from Tori (Seno Bankass) and Nafégué (Extreme South).

DISCUSSION

Alpha-tocopherol is predominant in shea butter. In a study of fatty acid and tocopherol patterns of variation, Allal *et al.* [9] reported that alpha-tocopherol was largely predominant with an average of 112 µg/g and gamma-tocopherol was second with an average of about 13 µg/g. According to Davrieux (laboratory results not published), these two tocopherols represent 99% of tocopherols content of Mali's shea butter.

Sites were found significantly different for tocopherols content all together as well as for each type of tocopherol. The northen sites (Dogon plateau and Seno Bankass) showed highest tocopherols content. Variation of tocopherols content according to sites and regions was reported in previous studies. Maranz & Wiesman [10] observed an increasing alpha-tocopherol content of shea nuts from the Guinean to the Sudanian zone. Allal *et al.* [9] reported that gamma-tocopherol content of Mali's shea butter was largely inferior to that of Uganda's shea butter.

CONCLUSION AND RECOMMENDATION

It is clear from these results that, the butter of the sites in the extreme north of *Vitellaria paradoxa's* (shea tree) distribution area in Mali (Dogon Plateau and Seno Bankass) has a proved content in tocopherols (vitamin E). This gives to the shea butter of this zone an important nutritional value for the good healf of rural populations because shea butter is the main source of fat for cooking in this area.

These sites, for most of the cases, were not significantly different from the site of Mperesso in the South, suggesting some research questions:

- do environmental and climatic conditions in the Exreme North have an influence on the genesis of tocopherols of shea butter?
- what would be the origin of shea trees of the Extreme North so that they showed high similarities with the shea trees of Mperesso in the South for tocopherols content as well as for other components of shea butter such as fatty acids?

It is important to investigate these research questions which are very important for improving knowledge of this usefull species and also important for the strategies of conservation, domestication and vegetal material improvement. Investigating the second research question will help understanding why shea populations of Daelan (Centre), geographically closer to the Extreme North (see map), were very different regarding tocopherols content.

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AUTHORS' CONTRIBUTIONS

Bokary Allaye Kelly: experimental design implementation, data collection and paper writing

Fabrice Davrieux: study protocol writing and data analysis

Jean-Marc Bouvet: study protocol writing, project coordination and paper writing.

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